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DEPARTMENT OF THE NAVY                                IGS-16363 (April 2004)
ATLANTIC DIVISION/EFAMED
NAVAL FACILITIES
ENGINEERING COMMAND                                -----
GUIDE SPECIFICATION                                Based on UFGS-16361N (09/99)
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IGS-16363

HIGH VOLTAGE SWITCHGEAR AND POWER TRANSFORMERS  
04/04

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NOTE: This guide specification covers the requirements for high voltage switchgear, high voltage power transformers, and circuit breakers, protective relays, and associated control devices. Pad-mounted transformers are specified in Section 16272, "Pad-Mounted Transformers ", and are to be specified only at European Activities at which pad mounted transformers are an accepted practice. Pole-mounted distribution transformers are specified in Section 16301, "Overhead Transmission and Distribution", and are to be specified only at European Activities at which pole mounted transformers are an accepted practice. High voltage/low voltage prefabricated substations are specified in Section 16364, "High Voltage/Low Voltage Prefabricated Substations." Low voltage switchgear and controlgear is specified in Section 16442, "Low Voltage Switchgear and Controlgear".

Comments and suggestions on this specification are welcome and should be directed to the technical proponent of the specification. A listing of the technical proponents and their telephone numbers is located on the LANTDIV website.

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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NOTE: The following information shall be indicated on the project drawings or specified in the project specifications:

1. Single-line diagram showing buses and interrupting devices; current transformers and voltage transformers (potential transformers) with

ratings; instruments and meters required; and description of instruments and meters.

2. Interrupting capacities.

3. Location and space available for switchgear, switches, transformers and auxiliary equipment.

4. Drawing showing desired arrangement of switchgear, switches, transformers and auxiliary equipment.

5. Grounding system plan and details.

6. Type and number of cables, and size of conductors for each power circuit, point of entry (top or bottom), and method of power cable termination (clamp-type terminals or terminators).

7. Minimum and maximum overall dimensions of shipping section which can be handled and installed at destination.

8. Special conditions, such as altitude, temperature and humidity, exposure to fumes, vapors, dust, and gases; and seismic requirements.

9. Where extensions or additions to existing switchgear or switches are being specified, clearly distinguish the difference between existing equipment and the equipment the Contractor is required to provide under this contract. Clearly indicate the extent of the Contractor's responsibility for testing the existing equipment upon completion of his work.

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## PART 1 GENERAL

### 1.1 REFERENCES

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NOTE: It is the Navy's goal to maximize the use of European technical/construction standards. Do not reference host nation standards that duplicate an available European standard. However, the designer is responsible for determining if there are any specific host nation standards that should be referenced. Also, consult with the project's Activity to determine their requirements, standards and preferences.

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The publications listed below form a part of this specification to the

extent referenced. The publications are referred to in the text by the basic designation only.

#### ITALIAN ELECTROTECHNICAL COMMITTEE (CEI)

CEI 7-6	(1997) Requirements for Checking Hot Galvanizing by Immersion on Ferrous Components Used in Lines and Electrical Installations
CEI 11-1	(1999; V1 2000; Errata Corrige 2001) Power Installations Exceeding 1 kV a.c.
CEI 14-8	(1999; V1 2002) Dry Type Power Transformers
CEI 14-13	(1998; V1 1998) Three Phase Oil-Immersed Distribution Transformers 50 Hz, from 50 kVA to 2500 kVA, with Highest Voltage for Equipment not Exceeding 36 kV. Part 1: General Requirements and Requirements for Transformers with Highest Voltage for Equipment not Exceeding 24 kV
CEI 17-1	(1998; V1 1999) High-Voltage Alternating-Current Circuit-Breakers
CEI 64-8	(2003) Electrical Installations of Buildings
CEI UNI EN 45510-2-3	(2000) Guide for Procurement of Power Station Equipment. Part 2-3: Electrical Equipment. Stationary Batteries and Chargers
CEI EN 60044-1	(2000; V1 2001, V2 2003) Instrument Transformers Part 1: Current Transformers
CEI EN 60044-2	(2001; V1 2003) Instrument Transformers - Part 2: Inductive Voltage Transformers
CEI EN 60060-2	(1998; V1 2000) High-Voltage Test Techniques Part 2: Measuring Systems
CEI EN 60076-1	(1998; V1 2002) Power Transformers Part 1: General
CEI EN 60076-2	(1998) Power Transformers Part 2: Temperature Rise
CEI EN 60076-3	(2002) Power Transformers Part 3: Insulation Levels, Dielectric Tests, and External Clearances in Air
CEI EN 60076-4	(2003) Power Transformers Part 4: Guide

	to Lightning Impulse and Switching Impulse Testing - Power Transformers and Reactors
CEI EN 60076-5	(2001) Power Transformers Part 5: Ability to Withstand Short Circuit
CEI EN 60076-10	(2002) Power Transformers Part 10: Determination of Sound Levels
CEI EN 60265-1	(2000) High-Voltage Switches Part 1: Switches for Rated Voltages Above 1 kV and Less Than 52 kV
CEI EN 60269	(Multiple Parts With Multiple Dates) Low Voltage Fuses (All Parts)
CEI EN 60298	(1998; Amend 2000) AC Metal-Enclosed Switchgear and Controlgear for Rated Voltages Above 1 kV and Up To and Including 52 kV
CEI EN 60529	(1997; Amend 2000) Degrees of Protection Provided By Enclosures (IP Code)
CEI EN 60694	(1997; Amend 2002) Common Specifications for High-Voltage Switchgear and Controlgear Standards
CEI EN 60896-2	(1997) Stationary Lead-Acid Batteries General Requirements and Methods of Test Part 2: Valve Regulated Types
CEI EN 60934	(2002) Circuit Breakers for Equipment (CBE)
CEI EN 61010-1	(2001; Errata Corrige 2002) Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part 1: General Requirements
EN 60726	(2003) Dry-Type Power Transformers
EN 62271-100	(2001; Amend 2002) High-Voltage Switchgear and Controlgear Part 100: High-Voltage Alternating-Current Circuit Breakers
CEI EN 62271-102	(2003) High-Voltage Switchgear and Controlgear Part 102: High-Voltage Alternating Current Disconnectors and Earthing Switches

## ITALIAN LAWS AND NORMS

D.P.R. 547	(27 April, 1955) Norms for Accident Prevention on Worksite
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LAW 46 (5 March, 1990) Safety Norms for  
Technological Systems

ITALIAN NATIONAL ASSOCIATION FOR UNIFICATION OF STANDARDS (UNI)

UNI 7545-7 (1976) Symbols for Danger Signs. Risk of  
Electric Shock.

UNI 8744 (1986) Paints and Varnishes - Test of  
Anticorrosion Resistance at 100% Relative  
Humidity

UNI EN 10088-1 (1997) Stainless Steels Part 1: List of  
Stainless Steels

## 1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," and Section 16081, "Apparatus Inspection and Testing" apply to this section, with the additions and modifications specified herein. Materials not considered to be high voltage switchgear material or components are specified in[ Section 16303, "Underground Electrical Work" ][ and][ Section 16402, "Interior Distribution System"].

## 1.3 DEFINITIONS

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**NOTE: Delete definitions of equipment not used in  
project specification.**  
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- a. Host Nation: The host nation is the nation in which the construction project is located and in which the construction work will actually incur.
- b. Projects in Italy must comply with Italian Laws and Norms, D.P.R. 547 (1955) Norms for Accident Prevention on Worksite; LAW 46, (1990) Safety Requirements for Electrical System.
- c. High Voltage Switchgear: High voltage switchgear are totally enclosed, free-standing electrical structures specifically designed to protect high voltage primary circuits and high voltage power transformers. Switchgear will consist of multiple overcurrent devices (drawout style circuit breakers) interconnected by a bus bar system and will include auxiliary equipment such as protective power relays and associated devices, voltage transformers, current transformers, associated control circuits, surge arresters, and so forth.

## 1.4 SUBMITTALS

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**NOTE: Submittals must be limited to those necessary  
for adequate quality control. The importance of an**

item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. Submit the following in accordance with Section 01330, "Submittal Procedures".

#### SD-02 Shop Drawings

High voltage switchgear assemblies; G

High voltage[ switches][ switchgear]; G

Power transformers; G

DC power system; G

[Alarm system; G]

#### SD-03 Product Data

High voltage switchgear assemblies; G

High voltage[ switches][ switch assembly]; G

Power transformers; G

DC power system; G

[Alarm system; G]

#### SD-05 Design Data

Capacity calculations for battery charger and batteries; G

Bus bars amperes; G

#### SD-06 Test Reports

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**NOTE:** Delete "ground resistance test reports" and the associated subparagraph if such tests are also

required in another section such as Section 16303, "Underground Electrical Work", or Section 16402, "Interior Distribution System". Define ground system tests only once in the specifications. All associated sections are to reference the section that defines the ground system test requirements. It is preferred to define ground system tests in Section 16303.

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Acceptance checks and tests; G

[Ground resistance tests; G]

[Field dielectric tests; G]

High Voltage[ Switches][ Switch Assembly][ Switchgear] Production Tests; G

#### SD-07 Certificates

High voltage switchgear design tests; G

High voltage[ switches][ switch assembly] design tests; G

High voltage circuit breakers (individually mounted style) design tests; G

Transformer design tests (liquid insulated); G

Transformer design tests (dry type); G

Schedule of Power Relay Settings and Calibrations; G

Request for final power relay settings; G

Equipment test schedule; G

#### SD-08 Manufacturer's Instructions

High voltage switchgear assemblies; G

High voltage[ switches][ switch assembly]; G

Power transformers; G

DC power system; G

#### SD-09 Manufacturer's Field Reports

High voltage switchgear production tests; G

Transformer routine and other tests (liquid insulated); G

Transformer routine and other tests (dry type); G

Transformer routine and other tests (cast resin); G

#### SD-10 Operation and Maintenance Data

High voltage switchgear assemblies, Data Package 5; G

High voltage[ switches][ switch assembly], Data Package 5; G

Power transformers, Data Package 5; G

DC power system, Data Package 5; G

[Alarm system, Data Package 5; G]

#### 1.4.1 Product Data

Each submittal shall include data on fuses, circuit breakers, switches, protective power relays and associated devices, meters, instrument transformers, surge arresters, and all associated accessories. Submittals shall show sectional views of cubicles. Provide manufacturer's instruction manuals for all[ protective power relays and associated devices][ and][ metering equipment,] including instructions of how to set and operate all component

#### 1.4.2 Acceptance Checks and Tests

Submit report of acceptance test results as specified by paragraph entitled "Field Quality Control".

#### [1.4.3 Ground Resistance Test Reports

Upon completion and before energizing electrical equipment, submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil condition at the time the measurements were made. Test the grounding system in accordance with specification section 16303, "Underground Electrical Work".

#### ]1.4.4 Manufacturer's Instructions

Submit the manufacturer's installation instruction manual within 30 days after receiving approved shop drawings and product data.

#### 1.4.5 Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01781, "Operation and Maintenance Data."

#### 1.4.6 Additions to Operation and Maintenance Manuals

In addition to requirements of Data Package 5, include the following on the

actual equipment provided.

- a. An instruction manual with pertinent items and information highlighted
- b. An outline drawing, including front view and sectional views with items and devices identified
- c. Prices for spare parts and supply list
- d. Routine and field acceptance test reports
- e. Time-current-characteristic (T-C-C) curves of breakers[ and fuses]
- f. Actual nameplate diagram
- g. Date of purchase
- [h. Information on[ protective power relays and associated protective devices][ and][ metering equipment] including the manufacturer's operational instruction manual.]

#### 1.5 QUALITY ASSURANCE

##### 1.5.1 Schedule of Power Relay Settings and Calibrations

- a. Ampere ratings of bus bars
- b. Maximum short-circuit bracing
- c. Circuit breaker type and ratings, continuous and load break rating
- d. Ratings and sizes of lugs
- e. Provision for future extension
- f. PCB content
- g. High voltage[ switches][ switch assembly] production tests
- h. High voltage[ switches][ switchgear]
- i. High voltage[ switches][ switch assembly][ switchgear] production tests
- j. Transformer routine and other tests (cast resin)
- k. Provide a Schedule of Power Relay Settings and Calibrations. The Contractor shall submit recommended settings of all protective power relays and associated devices. These values shall be based upon the recommendations of the manufacturer of the respective power equipment (high voltage switchgear/circuit breaker). These values are for comparison purposes relative to the intent of the original design. Include in the schedule the anticipated dates when equipment requiring coordination and protection will be installed, the anticipated date when the Contractor will request the list of final settings, and the

anticipated date when the manufacturer's technical representative will perform settings and calibrate equipment.

#### 1.5.2 Request for Final Power Relay Settings

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**NOTE: The "45" days in brackets below may be extended for projects involving major electrical distribution work.**

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- a. Final settings of the protective relays and associated devices will be provided by the Contractor in accordance with the relay setting coordination study provided by Government to achieve protection and coordination via relays and protective devices. Submit a request for power relay settings [45][ \_\_\_\_] days in advance of the date that settings will be needed, to allow the Contracting Officer sufficient time to obtain the final setting values from the responsible representatives.
- b. The equipment requiring protection and coordination shall be installed prior to making this request.

#### 1.5.3 Battery Power Calculations

Submit capacity calculations for battery charger and batteries. Calculation shall verify that battery capacity exceeds station DC power requirements.

#### 1.5.4 Ground Resistance Tests

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**NOTE: Delete "ground resistance test reports" and the associated subparagraph if such tests are also required in another section such as Section 16303, "Underground Electrical Work", or Section 16402, "Interior Distribution System". Define ground system tests only once in the specifications. All associated sections are to reference the section that defines the ground system test requirements. It is preferred to define ground system tests in Section 16303.**

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Upon completion and before final acceptance of the work, submit the measured ground resistance of each ground rod and grounding system, including the location of the rod and grounding system and soil conditions at the time the measurements were taken. Ground resistance tests shall be provided in accordance with Section 16303, "Underground Electrical Work".

## PART 2 PRODUCTS

### 2.1 GENERAL REQUIREMENTS

### 2.1.1 CE Marking and Display

Equipment, materials, components, assemblies and so forth which are subject to European Union (EU) economic directives shall have an approved Declaration of Conformity as demonstrated by an authorized display of the CE Mark (Conformite Europeene Mark). The CE Mark logo shall be placed on the product, the product literature, and/or packaging as required by the respective EU directive, or directives.

### 2.2 SOURCE MANUFACTURERS

The following manufacturers provide high voltage switchgear and power transformer materials that generally comply with these specifications:

- a. ABB S.p.A.  
Via Luciano Lama, 33  
20099 Sesto S. Giovanni (MI)  
Tel. (39) 02/2414.1  
Fax (39) 02/24142330  
www.abb.com/it
- b. Schneider Electric S.p.A.  
Direzione Generale  
Viale Colleoni, 7 - Palazzo Sirio  
20041 Agrate Brianza (Mi)  
Italia  
tel: (39) 39 655 8111  
fax: (39) 39 605 6237  
www.schneiderelectric.it
- c. Siemens S.p.A.  
Via Vipiteno, 42  
20128 Milano  
Tel. (39) 02/24362251  
Fax (39) 02/24362422  
www.siemens.it
- d. GEMMO Impianti S.p.A.  
Viale dell' Industria 2,  
36057 Arcugnano (VI)  
Tel: (39) 444 963990  
Fax: (39) 444 961551  
www.gemmo.com

### 2.3 PRODUCT COORDINATION

Products and materials not considered to be high voltage switchgear, switches, or circuit breakers, power transformers, and related accessories are specified in Section 16303, "Underground Electrical Work", Section 16430, "Low Voltage Switchgear and Controlgear", and Section 16402, "Interior Distribution System".

### 2.4 HIGH VOLTAGE CONDUCTOR TERMINATIONS

High voltage conductor terminations shall be designed for terminating one single conductor cable per phase and shall be arranged for circuits entering from below. Provide cable terminations as specified in Section 16303, "Underground Electrical Work".

## 2.5 HIGH VOLTAGE SWITCHGEAR ASSEMBLIES

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**NOTE: This paragraph is not intended to be used for generator control switchgear without extensive modification and coordination with applicable diesel engine generator guide specifications.**

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CEI EN 60060-2, CEI EN 62271-102, CEI EN 60265-1, CEI EN 60298, CEI EN 60694, and CEI 17-1. High voltage[ switches][ switchgear] shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Provide switchgear arrangement as indicated. Provide additional auxiliary sections as required to accommodate metering and control features (including instrument and control transformers) indicated, specified, or otherwise required or recommended by the switchgear manufacturer. Final arrangement shall be in accordance with the switchgear manufacturer's recommendations and approved by the Contracting Officer. Provide[ vacuum][ SF6] circuit breaker type, insulated for [5][15][24][\_\_\_\_] kV for use on [\_\_\_\_] kV system. Each steel unit forming part of the switchgear structure shall be self-contained and shall house circuit breaker or auxiliary equipment , and a full height center and rear compartment for the buses and outgoing cable connections. Equip individual circuit breaker compartments with drawout contacts, rails, disconnecting mechanism, and a cell interlock to prevent moving the removable element into or out of the "connected" position while the circuit breaker is closed. Provide a steel door for each breaker compartment. Enclosures shall be designed for indoor location and shall conform to CEI EN 60529 for the actual environmental conditions encountered. Design the structure to allow for future additions. Provide laminated plastic nameplates for each relay, switch, meter, device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each circuit breaker compartment door.

- a. Phase buses and connections: Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material and brace bus to withstand the mechanical forces exerted during short-circuit conditions when connected directly to a source having maximum of [\_\_\_\_] amperes rms symmetrical available. Bus bars amperes shall be rated [\_\_\_\_] and shall be high conductivity copper. Make bus bar connections from main buses to the incoming circuit breaker studs. Equip outgoing circuit breaker studs with mechanical clamp type cable connectors for the size of cables shown. Provide cable supports for outgoing cables.
- b. Ground bus: Provide a copper ground bus sized for full short-circuit capacity. Secure ground bus to each vertical structure and extend ground bus the entire length of switchgear. Include provisions for

making the station ground connections.

- c. DC bus: Provide an insulated copper bus or wire extending the entire length of switchgear. Bus shall be rated 100 amperes at 125 VDC. Wire shall be 10 mm<sup>2</sup> minimum.
- d. Each breaker compartment shall have provision for mounting one set of current transformers[ and a core balance current transformer (toroid)].
- e. Wire secondary circuits, including heater circuits, to terminal blocks. Terminal blocks shall be readily accessible for making external connections as required. Circuit breakers that serve low voltage auxiliary equipment shall be in accordance with CEI EN 60934. Fuses that serve low voltage auxiliary equipment shall be in accordance with CEI EN 60269.
- f. The switchgear, equipment and components shall be suitable and sized for installation inside a room with normal atmosphere, closed with limited ventilation, and indoor ambient temperature at 40 degrees C (maximum). Equipment and components shall be arranged so that: (1) ionization gases from one piece of equipment does not influence another; and (2) components which are heat sources do not damage or reduce the performance of adjacent components.
- g. Equipment subject to adjustments or replacement shall be positioned so that they are easily accessible from the front of the switchgear. Indicators, switches, push buttons and lamps shall be mounted in a position allowing reading and operation. Live parts of electrical circuits shall be located and protected in such a way that authorized personnel may carry out the following operations with the switchgear live and without any danger of accidental contact:
  - 1. Visual inspection of operating devices through suitable inspection openings.
  - 2. Operation of relays and disconnecting switches, inspection of indicating lights and instruments.
  - 3. Replacement of fuses, lamps, and so forth.
- h. The degree of protection of the enclosure shall be in accordance with CEI EN 60529 and shall be at least IP 30 for vertical parts. Exception may be made for components assembled on the enclosure doors and which do not need to be operated from the inside. Ventilation and drainage openings shall be at least IP 30. Access doors shall be hinged and fitted with key-operated handles. Panels and covers forming the enclosure shall be fastened with screws. The switchgear's enclosure panels shall have a minimum thickness of 2 mm with reinforcements where panels may be weakened due to large punchings. An exception may be made for internal sheets which are not part of the load bearing structure and external frame. These sheets shall have a minimum thickness of 1.5 mm. The switchgear baseplate shall consist of suitable frame provided with mounting bolts buried in the concrete floor slab.

- i. High voltage switchgear shall also comply with all requirements of the host nation.

#### 2.5.1 Circuit Breakers

EN 62271-100, CEI 17-1. Each circuit breaker shall be an electrically operated, three-pole, circuit interrupting device rated as indicated at maximum voltage of [\_\_\_\_\_] kV and [\_\_\_\_\_] kV BIL. Breaker shall be designed for service on a [\_\_\_\_\_] kV system with a short-circuit capacity of not less than [\_\_\_\_\_] [amperes symmetrical] [MVA]. Breaker frame size shall be as indicated. Circuit breaker shall be drawout-mounted with position indicator, operation counter, auxiliary switches, and primary and secondary disconnect devices. Circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provide for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment. Circuit breaker control voltage shall be [24][120][\_\_\_\_\_] VDC.

- a. Contacts: Silver-plated, multifinger, positive pressure, self-aligning type for main drawout contacts.
- b. Each drawout breaker shall be provided with three-position operation. The connected position and the test/disconnect position shall be clearly identified by an indicator on the circuit breaker's front panel.
  - 1. Connected position: Contacts are fully engaged. Breaker shall be tripped before it can be racked into or out of this position.
  - 2. Test/disconnect position: Position shall allow for complete testing and operation of the breaker without energizing the primary circuit.
  - 3. Withdrawn (removed) position: Places breaker completely out of compartment, ready for removal.

#### 2.5.2 Additional Requirements for Circuit Breaker Assembly

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**NOTE: Use this paragraph for high voltage switchgear at the Aviano Air Base in Aviano, Italy. It may be used (in whole or in part) at other project sites as approved by the respective Activity. Aviano uses a totally closed loop distribution system actually under restoration with a pilot wire system with multifunctional power relays with a microprocessor (designed as a Logic Selectivity Relay). The Zappala area uses a pilot wire system with state-of-the-art multifunctional power relays with a microprocessor (designated as a Logic Selectivity Relay).**

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Each circuit breaker assembly shall be an integrated assembly consisting of

the following subassemblies: (1) circuit breaker; (2) bus bar line switch; (3) line disconnect switch; (4) ground disconnect switch; and (5) potential capacitor assembly. Provide operational features as specified below. Operational variations may be considered and shall only be allowed where specifically approved by the Contracting Officer. Provide auxiliary components such as control and instrument transformers, measuring instruments, and power relays as indicated on the drawings and as specified hereinafter. Panel (door) covers on the front of the primary switch assembly shall include microswitches that are electrically interlocked with the bus bar line switch. When any panel cover is opened, the microswitch shall cause the bus bar line switch to open.

#### 2.5.2.1 Circuit Breaker

EN 62271-100, CEI 17-1. The circuit breaker shall be the SF6 circuit breaker type with a removable carriage assembly, mounted in its own cell and on suitable service skids. The service skids shall facilitate the breaker's extraction for inspection and maintenance operations. Each circuit breaker shall be equipped with the following features:

- a. Manual operation by means of pre-charged spring.
- b. Mechanical indication of "charged", or "not charged" spring mechanism.
- c. Auxiliary relay to indicate when circuit breaker is open.
- d. Auxiliary contacts.
- e. Mechanical interlock with the bus bar line switch.
- f. Plug-in outlet for auxiliary features, operated by the circuit breaker carriage.
- g. Electrical indication of the circuit breaker's open position (provide red pilot lamp) and closed position (provide green pilot lamp). Provide lamp assemblies with lamp test feature.
- h. Electrical characteristics shall be as follows:
  1. Rated voltage .....24KV
  2. Rated current .....630 A
  3. Rated frequency .....50 Hz
  4. Withstand voltage at 50 Hz for 1 minute .....50KV
  5. Impulse withstand voltage .....125 KV
  6. Short time current withstand 3 seconds .....16 KA
  7. Symmetrical breaking capacity .....14.5 KA at 20 KV  
equal to 500 MVA

8. Rated making capacity .....40 KA

#### 2.5.2.2 Bus Bar Line Switch

CEI EN 60265-1. Each circuit breaker assembly shall include a rotary type, bus bar line switch which shall isolate the circuit breaker from the switchgear's bus. The switch shall be mounted on resin epoxide insulators with high discharge surface of specialized construction to allow for installation in high moisture ambient and shall be resistant to partial power discharge. The switch shall provide separation between the bus bar and the circuit breaker with the circuit breaker either in its open position or close position. Provide switch with keyed interlock with the ground disconnect switch. Keyed operation shall allow the ground disconnect switch to be closed only when the bus bar line switch has first been opened. The bus bar line switch shall also be interlocked with the line disconnect switch. Both switches shall open simultaneously. Electrical characteristics shall be as follows:

- a. Rated voltage ..... 24 KV
- b. Rated current .....630 A
- c. Withstand voltage at 50 Hz for 1 minute .....50 KV
- d. Impulse withstand voltage .....125 KV
- e. Short time current withstand 1 second .....16 KA
- f. Dynamic limit current (peak) .....40 KA

#### 2.5.2.3 Line Disconnect Switch

CEI EN 60265-1. Each circuit breaker assembly shall include a rotary type, line disconnect switch which shall isolate the circuit breaker from the primary distribution system. Switch construction shall be the same as required for the bus bar line switch. Provide interlock with the bus bar line switch. Electrical characteristics shall be as follows:

- a. Rated voltage .....24 KV
- b. Rated current .....630 A
- c. Withstand voltage at 50 Hz for 1 minute .....50 KV
- d. Impulse withstand voltage .....125 KV
- e. Short time current withstand 1 second .....16 KA
- f. Dynamic limit current (peak) .....40 KA

#### 2.5.2.4 Ground Disconnect Switch

CEI EN 62271-102. Each circuit breaker assembly shall include a ground disconnect switch for the purposes of "grounding-out" the lower cell of the

switch assembly. The ground disconnect switch shall be designed to withstand 16 KA for 1 second at a voltage value of 24 KV. Provide the following features:

- a. Manual control on front of the primary switch assembly.
- b. Mechanism on the front of the primary switch assembly to indicate if the switch is open or if it's closed.
- c. Removable control lever.
- d. A keyed mechanical interlock with the bus bar line switch.

#### 2.5.2.5 Potential Capacitor Assembly

Each circuit breaker assembly shall include a potential capacitor assembly.

The potential capacitor assembly shall indicate if the lower cell of the switch assembly is electrically energized. The assembly shall include a small capacitor and disconnect switch with an indicator lamp. Whenever the lower cell is energized the lamp shall illuminate. Provide a lamp test switch. The assembly shall be rated for 24 KV.

#### 2.5.3 Space Only Compartments

Provide fully equipped with busing, control switch, indicating lights, and drawout breaker mounting and connecting straps to accommodate future breakers. Provide compartments with doors. Space shall be fully equipped and ready for activation by the simple insertion of the high voltage circuit breaker.

#### 2.5.4 Auxiliary Sections

Auxiliary sections shall have a hinged front panel, [ a [\_\_\_\_]-ampere, three-phase, [ three][ four]-wire[ insulated] main bus and connections, ] a ground bus, necessary terminal blocks, wiring and control buses, [ voltage transformer, ][ or][ control power transformer, ] and cable supports.

##### [2.5.4.1 Control Power Transformers

CEI 14-8. Transformers shall be designed for continuous operation at rated kVA 24 hours a day, 365 days a year with long life expectancy. Dry-type, two-winding type, [\_\_\_\_] degrees C rise above [\_\_\_\_] degrees C maximum ambient designed for mounting in switchgear cubicle or drawer. Transformer shall be sized as required to serve the connected load and shall have a voltage rating of [\_\_\_\_] kV three-phase, delta primary, and 220/380 V three phase, four wire, wye connected secondary, 50 Hz.

- a. Primary Protection: Provide [ drawout-mounted, ] primary current limiting fuses rated for the specified transformer size and the available short-circuit current.
- b. Secondary Protection: Provide compact (molded-case) circuit breakers in accordance with CEI EN 60934 and sized as required, mounted in same compartment with transformer and primary fuses to serve the indicated

loads.

#### ]2.5.4.2 Voltage Transformers

Provide voltage transformers as defined in the paragraph entitled "Control and Instrument Transformers".

#### 2.5.5 Breaker Lifter

Provide a portable lifter rated for lifting and lowering circuit breakers from cubicles. Portable lifter shall have swivel casters in front for ease of movement.[ Provide a lifter for each substation.]

#### 2.6 HIGH VOLTAGE[ SWITCHES][ SWITCH ASSEMBLY]

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**NOTE:** Specify one of the following styles of high voltage switches, conventional air switch versus a combination air switch with load interrupter. Consult with the Activity to determine their preferences and Station standards. A variety of high voltage switches are now available and each type has their advantages and disadvantages. This is also in comparison with high voltage circuit breakers, individually mounted style. Circuit breakers are more costly than fused switches, but may be needed where switching is frequent, and quick reclosing is required.

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CEI EN 60265-1. High voltage switches shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Fulfill all requirements of the host nation. Provide switches, accessories and features as indicated. Switches shall be insulated for [5][15][24][\_\_\_] kV for use on [\_\_\_\_\_] kV system. Each steel unit forming part of the switch structure shall be self-contained and shall house the switch and all accessories and features. Provide a full height center and rear compartment for the[ buses and] outgoing cable connections.[ Switches shall be designed and constructed for individually mounted style, floor mounted, free-standing type, totally self-contained.][

Provide high voltage switch assembly consisting of multiple, floor mounted, free-standing type switches connected to a common bus bar system. Provide switch layout as indicated. The entire assembly shall be designed and constructed as an integrated assembly.] Provide a steel door for each switch compartment. Enclosures shall be designed for[ indoor][ outdoor] location and shall conform to CEI EN 60529 for the actual environmental conditions encountered.[ Design the structure to allow for future additions.] Provide laminated plastic nameplates for each switch, meter, device, and cubicle to identify its function. Provide permanent labels for wiring and terminals corresponding to the designations on approved shop drawings. Mount nameplates on each compartment door.

#### [2.6.1 Conventional Air Switch

Provide a three-pole, single-throw, deadfront, metal-enclosed, load-break switch with manual stored energy operator. Switch shall be[ fused, with fuses mounted on a single frame][ non-fused] and designed for easy inspection [ and fuse replacement]. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be deenergized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. The door shall have an inspection window to allow full view of the position of the three switch blades through the closed door. Switch ratings shall be as follows:

- a. [\_\_\_\_\_] kV, [\_\_\_\_\_] kV BIL for service on a [\_\_\_\_\_] kV system with a fault close rating of not less than [\_\_\_\_\_] amperes asymmetrical.
- b. The switch shall be capable of carrying continuously or interrupting [\_\_\_\_\_] amperes with a momentary rating of [\_\_\_\_\_] amperes at [\_\_\_\_\_] kV.
- c. Switch shall have provision for padlocking in the open and closed positions.
- d.[ Fuses shall be current limiting type rated [\_\_\_\_\_] amperes continuous, and [\_\_\_\_\_] amperes interrupting capacity.][ Fuses shall be current limiting type rated approximately [\_\_\_\_\_] percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation.]

#### ] [2.6.2 Combination Air Switch With Load Interrupter

Provide a three-pole, single-throw, deadfront, metal-enclosed, load-break switch with load interrupter and manual stored energy operator. The switch shall consist of automatic, visible blade disconnects in series with[ vacuum][ or][ SF6] interrupters. Provide an interrupter for each phase. Switch shall be[ fused, with fuses mounted on a single frame][ non-fused] and designed for easy inspection[ and fuse replacement]. The switch shall be operated by a manually charged spring stored energy mechanism which shall simultaneously disconnect or connect ungrounded conductors. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability. A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus. Switch ratings shall be as follows:

- a. [\_\_\_\_\_] kV, [\_\_\_\_\_] kV BIL for service on a [\_\_\_\_\_] kV system with a fault close rating of not less than [\_\_\_\_\_] amperes asymmetrical.
- b. The switch shall be capable of carrying continuously or interrupting [\_\_\_\_\_] amperes with a momentary rating of [\_\_\_\_\_] amperes at [\_\_\_\_\_] kV.

- c. Switch shall have provision for padlocking in the open and closed positions.
- d. [ Fuses shall be current limiting type rated [\_\_\_\_\_] amperes continuous, and [\_\_\_\_\_] amperes interrupting capacity.][ Fuses shall be current limiting type rated approximately [\_\_\_\_\_] percent of the transformer full-load rating and in accordance with the fuse manufacturer's recommendation.]

#### ]2.6.3 High Voltage Switch Assembly

When indicated, provide multiple high voltage switches interconnected by a common bus bar system to form a switch assembly. [ Switch configurations shall be as indicated.][ The switch assembly configuration shall consist of: (1) a non-fused switch serving "power input"; (2) a non-fused switch serving "power output"; and (3) a fused switch serving the power supply to a transformer.] Switches shall be as specified above. The switch assembly shall include, but is not necessarily limited to, the following:

- a. Phase buses and connections: Mount bus structure on insulated supports of high-impact, non-tracking, high-quality insulating material and brace bus to withstand the mechanical forces exerted during short-circuit conditions when connected directly to a source having maximum of [\_\_\_\_\_] amperes rms symmetrical available. Bus bars shall be rated [\_\_\_\_\_] amperes and shall be high conductivity copper. Make bus bar connections from main buses to the bus studs serving the respective switches. Equip outgoing switch studs with mechanical clamp type cable connectors for the size of cables shown. Provide cable supports for outgoing cables.
- b. Ground bus: Provide a copper ground bus sized for full short-circuit capacity. Secure ground bus to each vertical structure and extend ground bus the entire length of switch assembly. Include provisions for making the station ground connections.

#### ]2.7 PROTECTIVE POWER RELAYS AND ASSOCIATED DEVICES

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**NOTE:** The definition and application of device function numbers used in electrical substations and switchgear are found in IEEE C37.2, "IEEE Standard Electrical Power System Device Function Numbers." The European power industry also uses these device function numbers. For description and application of commonly used relays, refer to MIL-HDBK-1004/3, "Switchgear and Relaying." This guide specification does not cover all possible relay applications. Choose only the relay types applicable to the specific project.

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Protective power relays and associated devices shall be solid-state type [ or induction type] enclosed in rectangular, semiflush, switchboard-type drawout cases with indicating targets and provisions for testing in place

by use of manufacturer's standard test blocks or test switches. One complete set of test blocks or test switches to fit each type of relay in the equipment shall be provided. Auxiliary and lockout relays are not required to have drawout cases or test provisions. Controls, relays, and protective functions shall be provided completely assembled and wired.

- a. Solid-state type relays with multiple functions may be submitted for consideration and approval by the Contracting Officer. Multiple functional relays may include additional features which are not specified. Protection and control functions that are provided and activated in addition to those functions that are specified shall be recommended by the equipment manufacturer and approved by the Contracting Officer.
- b. Additional functions that are provided but not approved shall be capable of being totally deactivated. Unused protection features shall not affect the proper operation of the relay protection system as intended in this design. This shall especially apply to instantaneous operational features which are undesirable when time delay features and selectivity features are required.

#### 2.7.1 Relay Requirements

Protective power relays and associated devices shall include, but not necessarily be limited to, the following:

- a. Phase overcurrent relays (device [50/]51): Provide [\_\_\_\_\_] sets of three time overcurrent relays responding to phase currents wired to trip associated circuit breakers upon the occurrence of a current above the tap setting of the relays. Each relay shall have inverse time characteristics with a tap range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes.[ Each relay shall be equipped with an instantaneous overcurrent unit having a pickup value over the range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes.][ Relays shall be Type [\_\_\_\_\_]..]
- b. Ground overcurrent relays (device [50/]51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have[ very][ extremely] inverse time characteristics with a tap range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes. Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [[\_\_\_\_\_] to [\_\_\_\_\_] amperes.][ Relays shall be Type [\_\_\_\_\_]..]
- c. Ground overcurrent relays (device 51N): Provide a time overcurrent relay responding to ground (residual) current, wired to trip the associated circuit breaker upon occurrence of ground current above the tap setting of the relay. Relay shall have[ very][ extremely] inverse time characteristics with a tap range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes.[ Relay shall be equipped with an instantaneous overcurrent unit having a pickup value adjustable over the range of [[\_\_\_\_\_] to [\_\_\_\_\_] amperes.][ Relays shall be Type [\_\_\_\_\_]..]
- d. Directional phase overcurrent relays (device 67): Provide [\_\_\_\_\_] sets

of three directionally controlled time overcurrent relays sensing phase current, wired to trip associated circuit breakers upon a current exceeding the tap setting in the direction indicated. Relays shall have a voltage polarized directional unit and an inverse time characteristic overcurrent unit. Overcurrent unit shall have a tap range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes.[ Relays shall be Type [\_\_\_\_\_]..]

- e. Directional ground overcurrent relays (device 67N): Provide directionally controlled time overcurrent relays sensing ground (residual) current. Relays shall be wired to trip the associated circuit breaker upon a current exceeding the tap setting in the direction indicated. Relays shall have a current and voltage polarized directional unit and an inverse time characteristic overcurrent unit. Relays shall be voltage polarized. Auxiliary potential transformers shall be provided to obtain polarizing voltage. Overcurrent unit shall have a tap range of [\_\_\_\_\_] to [\_\_\_\_\_] amperes.[ Relays shall be Type [\_\_\_\_\_]..]
- f. Lockout relays (device 86): Provide hand reset, electrically tripped, high-speed auxiliary relays where indicated. Relays shall be tripped by the indicated devices and shall be wired to trip the associated circuit breaker and prohibit closing of the circuit breaker by local and remote controls until the lockout relay has been reset by hand to its normal position. Each relay shall be provided with the number of contacts required to perform the indicated function and, in addition, shall have a minimum of two spare normally closed contacts and two spare normally open contacts.
- g. Bus differential relays (device 87B): Provide a set of three high-speed, high-impedance, single-phase bus differential relays, wired to trip the circuit breakers connected to the protected bus upon occurrence of a fault within the zone of protection. Relays shall not trip the circuit breakers on through current to a fault outside the zone of protection. Current signals shall be obtained from[ dedicated single ratio current transformers][ or][ bushing current transformers on the circuit breakers]. Bus differential relay shall include a voltage-operated unit which shall operate in three to six cycles for low-magnitude faults and a current-operated unit which shall operate in one to three cycles on moderate to severe faults. Relay shall include a thyrite voltage-limiting unit. Voltage-operated unit shall have an adjustment range of 75 to 500 V. Current-operated unit shall have an adjustment range of 2 to 50 amperes.
- [h. Trip blocking test switches: Trip blocking test switches shall be provided to block tripping of designated circuit breakers from the bus differential lockout relay. Trip blocking test switches shall be back-connected knife switches in a semiflush panel-mounted insulating case with removable clear glass or acrylic cover. Knife switches shall be rated for at least 125 Vdc and 30 amperes. Knife switches shall have an insulated operating knob.]
- i. Transformer differential relays (device 87T): Provide a set of three high-speed, percentage differential relays for protection of three-phase, delta-wye, two-winding transformer. Relays shall sense

phase currents from the transformer primary bushing current transformers and transformer secondary breaker current transformers. Relays shall trip the primary circuit breakers and the transformer secondary breakers. Relays shall have a sensitive differential unit to detect faults within the protected zone. Relays shall have a harmonic restraint unit to prevent tripping on transformer inrush current and two restraint transformers to prevent tripping on through-current to a fault outside the zone. Relays shall have a sensitivity of 0.35 times the tap value. Relays shall have ratio taps in the range of 2.9 to 8.7 amperes.[ Relays shall be Type [\_\_\_\_].]

- [j. Fault pressure relay (device 63): Provide a fault pressure relay sensitive to rate of rise of transformer tank pressure to detect internal faults in transformer windings. Fault pressure relay shall be wired to a compatible auxiliary seal-in relay (Device 63X), which shall trip primary circuit breakers and transformer secondary breakers of the associated transformer via a lockout relay. Fault pressure relay shall be transformer mounted and auxiliary relay shall be panel mounted in a semiflush case. Auxiliary relay shall have trip-indicating targets.]
  
- k. Thermal relay (device 49): Provide a winding thermal relay, with associated accessories including an electronic control unit. Equipment shall indicate the winding temperature of the transformer and shall serve the electronic control unit. The control unit shall provide automatic cooling fan control and shall serve the alarm system to provide a high temperature alarm feature and a high-high temperature shutdown feature.[ Provide features necessary for remote indication of high temperature alarm and high-high temperature shutdown and connection to[ an existing remote central monitoring system][ a future Supervisory Control and Data Acquisition (SCADA) System.]][[ The existing remote central monitoring system is made by [\_\_\_\_],[ model number [\_\_\_\_]][ style/type [\_\_\_\_]].] The new system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment to the existing remote central monitoring system.]
  
- l. Auxiliary control relays: Provide as required to implement protective functions and interlocking as indicated. Auxiliary relays shall have contacts rated to carry 30 amperes for one minute and 12 amperes continuously. Coils shall be a long-life design with a projected service life of 40 years.
  - 1. Auxiliary relays used for tripping circuit breakers shall be multicontact, high-speed relays operating in one-half cycle or less.
  - 2. Auxiliary relays for functions other than tripping circuit breakers shall be normal-speed relays operating in two cycles or less.
  - 3. Auxiliary timing relays shall be[ solid state][ or][ electro-pneumatic] relays with contacts rated for at least the load they are controlling.

## 2.7.2 Multifunctional Power Relay (MPR) Units

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**NOTE:** Use this paragraph for high voltage switchgear at the Aviano Air Base in Aviano, Italy, but only in the Zappala area. It may be used (in whole or in part) at other project sites as approved by the respective Activity. Aviano uses a totally closed loop distribution system actually under restoration with a pilot wire system with multifunctional power relays with a microprocessor (designed as a Logic Selectivity Relay).

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All the basic protection, measurement, operation, control and monitoring functions shall be performed by the MPR units. The units shall be the state-of-the-art electronic type, microprocessor based with modular construction. The operating temperature shall be from -5 degrees C to + 55 degrees C. The MPR units shall be designed to accommodate all types of auxiliary power supply voltages (24, 48, 127, 220 VDC); all types of current sensors (1A, 5A, CT); or magnetic sensors; and all types of voltage sensors (100, 100V VT, 100/110/VT). The design and manufacturing process shall be ISO 9001 certified. The units shall be of the disconnectable and withdrawable type to facilitate replacement. It should be possible to withdraw the units without prior current circuit short-circuiting. All wiring terminals shall accommodate 2.5 mm<sup>2</sup> wiring through 6 mm<sup>2</sup> wiring. The output relays shall be capable of withstanding steady state current of 8 amps. The logic inputs shall have the same voltage rating as the auxiliary power supply and shall comply with the standards relative to programmable logic controllers (PLC's). The logic input current shall be at least 4 milliamps.

### 2.7.2.1 Operating Dependability

The MPR units shall include, but not necessarily be limited to, the following:

- a. An internal function self-monitoring mechanism which activates two fail-safe watchdog changeover contacts.
- b. An automatic device for switching to the fail-safe position. The device shall disable the output controls when any major internal failure is detected.
- c. Indication on the front of the device by signal lamps and messages indicating self-test status.

### 2.7.2.2 Protection and Operational Features

As a minimum condition, each MPR unit shall contain the protection and operational features indicated on the drawings. An MPR unit may have additional available protection features, but shall not be activated unless specifically approved by the Contracting Officer. Unused features shall

not affect the proper operation of the MPR units as intended in this design. This shall especially apply to instantaneous operational features which are undesirable when time delay features and selectivity features are required. Each protection device shall have a wide range of settings, especially for overcurrent protection, thus providing a choice of curve types. Overcurrent protection features shall include definite time (DT) selection features and multiple inverse time (IDMT) features including standard inverse time (SIT), very inverse time (VIT), and extremely inverse time (EIT). Overcurrent protection features shall also include instantaneous setting (defined at 50 milliseconds) and multiple time delay settings up to a maximum of 500 seconds. Overload protection shall be based on "through RMS current" value (up to the 17th harmonic). Setting shall be performed by the direct input of primary current values. Sensitive earth fault pick-up may reach 100mA primary. The unit shall allow for the use of upstream and downstream logic discrimination (via the logic selectivity relays), including the use of multiple inverse time settings (SIT, VIT, and EIT). Alternative overcurrent setting groups shall be selected to quickly incorporate revised protection schemes. (This is to allow for multiple power sources within the closed loop circuit; that is, closed network.) Protection tripping shall be indicated on the front of the MPR unit by a signal lamp and a message indicating the cause of the fault.

#### 2.7.2.3 Electrical Measurement Features

Provide MPR units with electrical measurement features where indicated on the drawings (symbol DMM for digital multimeter). Additional metering may be provided as a function of a manufacturer's standard catalog product.

a. Electrical measurements shall include the following:

1. Each phase current, instantaneous values.
2. Each phase current, maximum demand.
3. All line voltages.
4. Power factor.
5. Instantaneous power.
6. Maximum power demand.
7. Frequency.
8. Active and reactive energy values.
9. Each phase tripping currents.

b. Minimum measurement accuracy shall be 1.5% for active and reactive power and 1% for currents and voltages.

#### 2.7.2.4 Display Features

Each MPR unit shall include an alphanumeric display unit. Display indication shall be visible from at least 2 meters. Messages shall be in English and [Italian][\_\_\_\_\_]. The display unit shall display all electrical measurements and all device and maintenance messages. Circuit breaker's position (open or closed) shall also be displayed on the front of the MPR unit by two signal lamps. Circuit breaker settings and performance parameter settings shall be accomplished by a hand-held portable terminal unit or by a remote personal computer. Access to setting mode shall be protected by a personal customized password of at least 5 characters.

#### 2.7.2.5 Control and Monitoring Features

Provide a complete and operational system specifically designed for local control and monitoring, and operation with and connection to an existing central control and monitoring (that is, remote monitoring system). Control and monitoring features shall be accomplished by a state-of-the art microprocessor with programmable features, hereinafter referred to as the programmable automation system (PAS). Remote control and monitoring shall be accomplished by a communication network system with a series communication port feature using MODBUS/JBUS protocol. Communication between each substation and the existing central system shall be accomplished by a single pair, telephone cable.

#### 2.7.2.6 Remote Control and Monitoring Features

The MPR units shall be fully equipped for the direct connection of communication cable(s) (communication link) to the existing central control and monitoring system. A substation's final system connection to the existing central system shall be accomplished by a two twisted and shielded copper[ multimode fiber optic cable][ 12][ 24][ strands] conductor cable system and shall be transmitted over a standard pair of telephone wires[ multimode fiber optic cable]. This cable connection shall fulfill and execute all input and output signals and functions. The MPR units shall include all hardware features, components, accessories, and so forth, for operation with the existing central control and monitoring system. This shall include cable connection features necessary to prevent inductive coupling. The new control and monitoring system shall be totally compatible with the existing central control and monitoring system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment to the existing control and monitoring system. The existing central control and monitoring system is made by [\_\_\_\_\_] and is the [\_\_\_\_\_] unit.

#### 2.7.2.7 Control and Monitoring Functional Requirements

Controls and monitoring features (local and remote) shall be as follows:

- a. Circuit breaker's open and close control and position status.  
Coordinate with the actual types of control coils furnished (shunt-trip coil, under-voltage release coil, latching contactor with shunt-trip coil, and so forth).
- b. Trip circuit supervision.

- c. Operation counter.
- d. Phase fault trip counter.
- e. Detection of plugged connectors (watch dog feature).
- f. Logic selectivity features (in conjunction with lockout features and inhibit closing features) specifically designed to isolate a faulted cable between two substations.
- g. Special operations of external features such as transformer's high temperature.
- h. The remote monitoring functions shall also include the following:
  - 1. All electrical measurements.
  - 2. Alarm features and status.
  - 3. Logging and storing of status changes.
  - 4. Print out of operating reports.

#### 2.7.2.8 Programmable Automation System (PAS)

The PAS shall consist of logic inputs, output relays, internal relays, timers, event counters, output contacts, and other components and features necessary to provide a complete and useable system. Output relays shall operate in accordance with the state of the logic inputs and the outputs of the protection functions. The program shall be written in "electrical ladder language". All programming shall be performed by a qualified technician of the high voltage switchgear manufacturer, also referred to as the "power relay technician".

- a. Logic inputs: 10 minimum with expandability to 26.
- b. Output relays: 6 minimum with expandability to 14.
- c. Internal (software) relays: 256, utilized for standard operational features.
- d. Timers: 60, adjustable from 50 milliseconds to 655 seconds.
- e. Event counters: 16, unaffected by loss of power.
- f. Pre-programmed messages per event: 32 at 11 characters per message.
- g. Predetermined internal relays: 25, utilized to access information external of the PAS.
- h. Programmable internal relays: 32, controlled by the hand held pocket terminal unit or by a remote personal computer.
- i. Communication port internal control relays: 64, controlled and

activated by the remote personal computer.

- j. Communication port internal monitoring relays: 32, utilized for remote monitoring purposes and displayed on the remote personal computer.

#### 2.7.2.9 Protective Power Relay and Associated Devices

Unless otherwise noted, all power relays and other associated relays shall be provided by the manufacturer of the high voltage switchgear. All relays shall be integrally designed for the proper operation of the high voltage switchgear. All power relays and other associated relays shall be the state-of-the-art electronic type and shall be an integral element of the MPR units. Coordinate with the DC power system and the alarm system.

- a. Thermal Relays (Device 49): The thermal relay (thermal image) shall be provided by the switchgear manufacturer and shall be an integral element of the MPR unit. The relay shall be electronic type. The relay shall include a "prehigh alarm" feature and a "high-high shutdown" feature. The relay shall have the number of contracts required to fulfill the functional operations defined on the drawings and in the specifications. The type of contacts (normally opened versus normally closed) and electrical ratings of contacts shall be coordinated with the requirements of the high voltage switchgear and alarm system. Temperature activation settings shall be as recommended by the transformer manufacturer. Coordinate in all aspects with the transformer manufacturer.
- b. Instantaneous Overcurrent Relays (Device 50): The instantaneous overcurrent relay shall be the electronic type and shall be an integral element of the MPR unit. The unit shall be a low burden, sensitive, instantaneous overcurrent relay designed to provide protection in case of abnormal system conditions. The unit shall have a wide sensitivity range and shall be adjustable. The unit shall also have an adjustable definite time delay feature. Provide, at a minimum, one form C contact and operation indications (for each phase). The relay shall meet or exceed the previously defined characteristics. If instantaneous overcurrent relays are included as a standard feature within the MPR unit for which logic selectivity features are required, the instantaneous feature shall be totally isolated and removed from operation. The shop drawings shall specifically address this concern.
- c. Overcurrent Relay with Time Delay (Device 51): The overcurrent relay with time delay shall be the electronic type and shall be an integral element of the MPR unit. The unit shall be a low burden, sensitive, overcurrent relay with time delay designed to provide protection in case of abnormal system conditions. The unit shall have a wide sensitivity range and shall be adjustable. The unit shall also have an adjustable definite time delay feature. Provide at a minimum one form C contact and operation indications (for each phase). The relay shall meet or exceed the previously defined characteristics.
- d. Ground Overcurrent Relays (Device 51G): The ground overcurrent relay shall be the electronic type and shall be an integral element of the MPR unit. The unit shall be a low burden, sensitive, ground

overcurrent relay designed to provide protection in case of abnormal system conditions. The unit shall have a wide sensitivity range and shall be adjustable. The unit shall also have an adjustable definite time delay feature. Provide at a minimum one form C contact and operation indications. The relay shall meet or exceed the previously defined characteristics.

- e. Ground Fault Protection Relays (Device 51N): Provide electronic type ground fault protective devices integral with the MPR unit. Provide each relay with time delay suitable for protecting circuit components against phase to ground faults. Provide each relay with two independent output contacts and operation indications. The relay shall meet or exceed the previously defined characteristics.
- f. Directional Phase Overcurrent Relays (Device 67): Provide electronic type directionally controlled time overcurrent relays sensing phase current, wired to trip associated circuit breakers upon a current exceeding the tap settings. Relays shall have a current direction as required to provide proper operation as intended. Relays shall be an integral element of the MPR unit. Relays shall have a voltage polarized directional unit and an inverse time characteristic overcurrent unit. Overcurrent units shall have a multiple tap range with sufficient variability to provide proper selectivity, protection, and isolation of the closed loop circuit (closed network). Relays shall be coordinated with the logic selectivity relay (Device 95).
- g. Directional Ground Overcurrent Relays (Device 67N): Provide electronic type directionally controlled time overcurrent relays sensing ground (residual) current. Relays shall be an integral element of the MPR unit. Relays shall be wired to trip the associated circuit breaker upon a current exceeding the tap settings. Relays shall have a current and voltage direction as required to provide proper operation as intended. Relays shall have a current and voltage polarized directional unit and an inverse time characteristic overcurrent unit. Relays shall be voltage polarized. Auxiliary potential transformers shall be provided to obtain polarizing voltage. Overcurrent unit shall have a multiple tap range with sufficient variability to provide proper selectivity, protection, and isolation of the closed loop circuit (closed network). Relays shall be coordinated with the logic selectivity relay (Device 95).
- h. Logic Selectivity Relays (Device 95): The logic selectivity relays (logic discrimination) shall be the electronic type and shall be an integral element of the MPR unit. The logic selectivity relays shall provide very quick selectivity tripping of the phase overcurrent and earth fault protection relays, whether definite time (DT) or inverse time (IDMT with SIT, VIT or EIT operations). The logic selectivity function shall trigger the transmission of a blocking input signal (via the pilot wire system) whenever one of the protection settings are exceeded. Upon an occurrence of a cable fault, the appropriate overcurrent relays shall trip the circuit breakers connected to both ends of the protected cable, thus creating a "zone of protection". The blocking input signal shall prevent the tripping of circuit breakers which are outside the zone of protection. Consequently, the faulted

cable shall be totally and safely isolated without shutting down any of the substations connected on the closed loop circuit (closed network). The high voltage switchgear manufacturer shall submit short circuit calculations and recommend settings of all MPR units. These values shall be used to confirm the design selections and settings. Submit calculations in both English and [Italian][\_\_\_\_\_].

1. Pilot wires shall be double shielded, twisted pair, 0.65 mm<sup>2</sup> (#19 AWG) or larger. Pilot wires shall be run with the primary distribution system (provide a dedicated conduit located below the ductbank structure) and thus interconnect adjacent substations. Install wires in a 50mm rigid PVC conduit located underneath the primary cable's ductbank system. In manholes and substations, the pilot wires shall be installed in 20mm rigid steel conduit. Provide junction boxes for wire pulling purposes. Terminate the pilot wires in a manner which prevents inductive coupling. The Contractor shall fulfill all instructions and recommendations of the high voltage switchgear manufacturer.

- i. Auxiliary Control Relays (Device 96): The auxiliary control relays shall be considered a part of the alarm system but may be incorporated (in whole or in part) with the MPR unit. The Contractor shall fully coordinate the interconnections and integration of the alarm system and the high voltage switchgear. It is desired to have the alarm system provided by the high voltage switchgear manufacturer. See the paragraph entitled "ALARM SYSTEM".

## 2.8 CONTROL AND INSTRUMENT TRANSFORMERS

### 2.8.1 Current Transformers

CEI EN 60044-1. Transformers shall be single ratio as indicated, 50 Hz, and coordinated to the rating of the associated switchgear, relays, meters, and instruments. Transformers shall be manufactured with fire resistant epoxide resin resistant to partial power discharge. Electrical characteristics shall be as follows:

- a. Rated voltage ..... [24][\_\_] KV
- b. Step down ratio .....As indicated
- c. Withstand voltage at 50 Hz for 1 minute .....50 KV
- d. Impulse withstand voltage .....125 KV
- e. Thermal current for 1 minute .....16 KA
- f. Dynamic and rated current .....2.2 I term
- g. Precision class of measurement .....0.5%
- h. Precision class of protection .....5.P.
- i. Safety factor of performance .....10

j. Minimum performances .....Adequate

## 2.8.2 Voltage (Potential) Transformers

CEI EN 60044-2, CEI EN 60269 and CEI EN 60934. Transformers shall be[ stationary][ drawout] type, 50 Hz, with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, meters, and instruments. Transformers shall have[ one fuse][ two fuses][ three fuses] in the primary. Each phase conductor of the secondary shall also have fuse or circuit breaker protection. Fuses shall be current limiting and sized as recommended by the voltage transformer manufacturer. Transformers shall be manufactured with fire resistant epoxide resin resistant to partial power discharge. Electrical characteristics shall be as follows:

- a. Rated voltage ..... [24][\_\_] KV
- b. Transformer ratio .....As indicated
- c. Withstand voltage at 50 Hz for 1 minute .....50 KV
- d. Impulse withstand voltage .....125 KV
- e. Precision class for measurement .....0.5%
- f. Minimum performance .....Adequate

## 2.9 ELECTRICAL METERING

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**NOTE:** Coordinate with the Activity to determine Station requirements, preferences and any special requirements for connecting to existing basewide monitoring systems, if any. Not all high voltage switchgear warrant metering. Be sure to show metering on the drawings both on the electrical power diagrams and on the elevation view of the high voltage switchgear. Also, current transformers and voltage (potential) transformers (sizes and quantities) must be defined on the drawings. Do not specify waveform capture features and communication features unless specifically instructed. Drawings must also define where meters with circuit monitoring functions are specifically required.

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Provide switchboard style, electronic, digital multimeters with quantity and locations as indicated on the drawings. Meters shall be the semi-drawout, semi-flush mounted type and mounted on the panel cover of the high voltage switchgear. Meters shall be coordinated with the electrical system requirements and shall conform to CEI EN 61010-1. Meters shall measure true RMS values through the 31st harmonic value, shall have a minimum accuracy of [1.0][\_\_] percent. Meter display readings shall be

direct values and shall not require any multiplier factors. Provide fuse protection for each phase conductor of the voltage supply circuit. Fuses shall comply with CEI EN 60269 and shall be selected and sized as recommended by the meter manufacturer. Provide a current transformer for each phase of the electrical system and coordinate the meter with ratios of the transformers. The meter shall also be properly coordinated with the voltage transformers and the circuit properly protected. The meter shall include local display with a two line by 16 character LCD screen for the readout of all metered and diagnostic values. Values shall be defined to six digits. Meter shall include local operational features for "selection and mode" functions and scrolling features to observe the metered values. Setup and reset features shall be password protected and easily accomplished through the meter's display system.

#### 2.9.1 Measured Values

Measured values shall include, but not necessarily limited to, the following:

- a. Current each phase and in the neutral (A).
- b. Line-to-line voltages (V).
- c. Line-to-neutral voltages (V).
- d. Real power (kW).
- e. Reactive power (kVAR.)
- f. Apparent power (kVA).
- g. True power factor (PF).
- h. Frequency (Hz).
- i. Real energy (kWh).
- j. Reactive energy (kVARh).
- k. Apparent energy (kVAh)
- l. KYZ output (pulse initiation feature for remote energy monitoring) with connection features to central monitoring station.
- m. Total harmonic distortion (THD) for current and voltage.
- n. Demand current (A).
- o. Real power demand (kWd).
- p. Reactive power demand (kVARd).
- q. Apparent power demand (kVAd).

r. Date/time stamping.

#### [2.9.2 Digital Multimeters With Circuit Monitor Functions

Digital multimeters with circuit monitor functions shall be the same as defined for digit multimeters except that they shall also have programmable circuit monitoring functions as defined below. Quantity and locations of these enhanced meters shall have a communication port located on the front of the meter. The port shall serve a handheld programming unit which shall be used to program the meter, reset values, download data stored in memory, and similar functions. Provide [one][\_\_\_\_] handheld programming unit[s] and turn over to the Contracting Officer.[ The meter shall also be capable of being programmed and downloaded by an existing, central monitoring station (that is, remote monitoring). Provide all programming software necessary to download, analyze, evaluate and document the data retrieved and stored by the meter. The program shall include customized report documentation and printout features. Provide an instruction manual for loading and operating the associated programs. Programs shall be designed for use on a personal computer with Microsoft operating systems.] The additional measured values and diagnostic features shall include, but not necessarily limited to, the following:

- a. Onboard alarms (under/over conditions and phase unbalance conditions).
- b. Minimum/maximum readings for current, voltage, power, power factor, frequency and THD values.
- c. Data and event logging.
- [d. Waveform capture.]
- [e. Communication features for reporting all measured parameters and diagnostic features to the existing central monitoring system. The existing system is manufactured by [\_\_\_\_], model number [\_\_\_\_], and includes a [\_\_\_\_] communication protocol system. The metering equipment provided and its associated communication system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment with the existing system.]

#### ]2.9.3 Watthour Meters

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**NOTE: Use this paragraph only if digital  
 multimeters are not specified and the Activity  
 desires power monitoring.**  
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CEI EN 61010-1, CEI 64-8. Provide a switchboard style electronic programmable watthour meter, semi-drawout, semi-flush mounted, as indicated. Meter shall either be programmed at the factory or shall be programmed in the field. When field programming is performed, turn field programming device over to the Contracting Officer at completion of the project. Meter shall be coordinated with the electrical system

requirements and shall conform to CEI 64-8 and CEI EN 61010-1.

- a. Design: Provide meter designed for use on the voltage system specified. Provide 3 current transformers. The meter shall also be properly coordinated with the voltage transformers and the circuit properly protected. Provide meter with KYZ pulse initiation hardware.[ Meter shall be fully equipped for the direct and simple connection to a future central monitoring system.][ Connect meter to the Station's existing central monitoring system. The existing system is manufactured by [\_\_\_\_], model number [\_\_\_\_], and includes a [\_\_\_\_] communication protocol system. The metering equipment provided and its associated communication system shall be totally compatible with the existing system. The Contractor shall be totally responsible for coordinating and interfacing all interrelated equipment with the existing system.]
- b. Coordination: Provide meter coordinated with ratios of current transformers and voltage (potential) transformers.
- c. Accuracy: +/- 1.0 percent.
- d. Kilowatt-hour Register: 5 digit electronic programmable type.
- e. Demand Register:
  1. Provide solid state type.
  2. Provide a direct reading meter. A multiplier factor shall not be required.
  3. Provide demand interval length programmed for[ 15][ 30][ 60] minutes with rolling demand up to six subintervals per interval.
- f. Meter fusing: CEI EN 60269. Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

## 2.10 HEATERS

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**NOTE: Provide electric circuit (or circuits) for heaters mounted in the electrical equipment. Show all circuits on the drawing floor plan and in panelboard schedule.**  
 \*\*\*\*\*

Provide one electric heater in each vertical section of the high voltage overcurrent protection equipment . Heaters shall be rated 220 V, shall have sufficient capacity to control moisture condensation in the compartments, and shall be sized 250 watts minimum. Heaters shall be controlled by a thermostat[ and humidistat] located inside the equipment. Thermostats shall be industrial type, high limit, to operate on temperature rise, with range of 15 to 32 degrees C.[ Humidistats shall have a range of

30 percent to 60 percent relative humidity.] Heaters shall be electrically supplied from a local panelboard. Energize electric heaters while the equipment is stored or in place prior to being placed in service.

## 2.11 PILOT AND INDICATING LIGHTS

Provide pilot and indicating lights as indicated, as specified, and as otherwise required or recommended by the manufacturer of the respective electrical power equipment. Lights shall be transformer, resistor, or diode type. Color of lens covers shall be as indicated. Where the lens color is not specified, provide a color that is recommended by the equipment manufacturer. Each light shall have a legend plate which defines the function that is being indicated. (Examples: open, closed, tripped, and so forth.)

## 2.12 POWER TRANSFORMERS

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NOTE: Indicate and specify the type of transformer (or transformers) required for the project. This includes: (1) interior installation versus exterior installation; and (2) liquid insulated type versus dry type. Selection and design shall be based upon the following:

1. Outdoor mounted transformers shall only be specified where specifically required by the Activity.
2. Consult with the Activity regarding preferences for transformer type (liquid insulated versus dry type). The designer must be aware of environmental requirements of the host nation. Oil insulated transformers may require spill containment systems that are expensive and require significant space and underground burial.
3. As a result of the environmental issues, the Aviano Air Base (Aviano, Italy) requires dry type transformers that must be mounted indoors.
4. If liquid insulated transformers are specified, then specify mineral oil-filled transformers wherever possible. Less-flammable liquid-insulated transformers may be used as approved by the Activity and when installed in accordance with the host nation's safety and environmental requirements. For interior liquid-filled transformers comply with all requirements defined in MIL-HDBK-1008, "Fire Protection for Facilities Engineering, Design, and Construction" and with the host nation's safety and environmental requirements.
5. If it is anticipated that future load

requirements will necessitate increasing the capacity of the transformer, the specification for the transformer should require the provision of components and brackets for future forced air cooling and mechanical circulation for the coolant fluid (if liquid insulated).

6. If forced-air-cooling is immediately specified, define such requirements on the drawings, provide associated details, and define the operational control features.

\*\*\*\*\*

CEI EN 60076-1, CEI EN 60076-2, CEI EN 60076-10. Power transformers shall be approved and listed by a recognized European safety organization and shall have a "mark of quality" from such an organization. Transformers shall be [ oil-insulated][ less-flammable liquid-insulated][ dry type] rated [\_\_\_\_\_] kVA, [ forced-air-cooled,] 50 Hz, three-phase, [\_\_\_\_\_] kV, [\_\_\_\_\_] kV BIL, primary connected [ delta][ wye] to [\_\_\_\_\_] V secondary connected [ delta][ wye]. High voltage bushings and low voltage bushings shall be coordinated to provide the optimum connections to the respective high voltage and low voltage circuits and the associated equipment to which the transformer is connected. Bushings shall be accessible for connection, inspection and maintenance purposes. [ Forced-air-cooling fans shall have [ automatic temperature control unit][ winding temperature indicator with sequence contacts].] Minimum tested impedance shall be not less than [\_\_\_\_\_] percent. Transformers shall have [four][\_\_\_\_\_] externally operated 2 1/2 percent full capacity taps, [two][\_\_\_\_\_] above and [two][\_\_\_\_\_] below rated voltage. Provide low-voltage neutral bushings on units having wye-connected low-voltage windings. Transformer shall have stainless steel diagrammatic nameplate. Transformer's sound levels shall be in accordance with CEI EN 60076-10.[ All transformers shall be designed and approved for parallel operation. Provide matching and electrically identical transformers that are parallel connected.][ Transformer shall have fully equipped provisions for the future and simple addition of automatically controlled cooling fans.]

#### 2.12.1 [Liquid Insulated ][Less-Flammable Liquid Insulated ]Transformers

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NOTE: 55/65 degrees C rise provides an additional 12 percent kVA capacity when the unit is operated at 65 degrees C. This is a safe means of overloading the base kVA rating of a transformer without affecting its life. Additional cost for 55/65 rise is minimal when compared to the purchase of the next larger standard kVA size unit.

\*\*\*\*\*

CEI 14-13. [ Liquid insulated][ Less-flammable liquid insulated] transformers shall have an insulation system rated [ 55/65][ 65] degrees C rise to allow transformers to have a continuous overload capacity of 12 percent at rated voltage without exceeding 65 degrees C winding temperature rise above 40 degrees C maximum ambient. Provide identification of

transformer as "non-PCB" on the nameplate.[ The insulated liquid shall be a mineral oil that complies with the requirements of CEI 14-13.][ The less-flammable insulated liquid shall comply with the requirements of CEI 14-13 and shall have a fire point not less than 300 degrees C and a dielectric strength not less than 33 kV. Do not provide nonflammable transformer liquids including askarel and insulating liquids containing polychlorinated biphenyls (PCB's), tetrachloroethylene (perchloroethylene), chlorine compounds, and halogenated compounds.] Each transformer shall include the following devices.

- a. Pressure-vacuum gauge.
- b. Bucholtz relay and associated control circuitry.
- c. Pressure relief device.
- d. Dial-type thermometer.
- e. Liquid-level gauge, dial type.
- f. Drain valve with sampling device.
- g. Upper filter plug.
- h. Ground connection provisions.
- i. Lifting lugs (4 minimum).
- [j. Electronic type temperature alarm and control unit with: (1) high temperature alarm feature; (2) high-high temperature shutdown feature; (3) all control devices for operating automatically controlled cooling fans, and (4) all associated control circuitry. Provide a separate temperature sensor or combine operations with the dial-type thermometer.]

#### 2.12.2 Dry Type Transformers

EN 60726, CEI 14-8. Dry type transformers shall be the cast resin type, thermal class[ F][ H], Dyn 11 vector group, and provided with a ventilated metal enclosure. Enclosure shall be rated [IP 31][\_\_\_] (except the bottom may be rated [IP 21][\_\_\_]) in accordance with CEI EN 60529. The transformer's core shall be composed of magnetic sheets, grain oriented, cold laminated and provided with mineral oxide insulating material. All magnetic sheets shall be treated with corrosion protection. High voltage and low voltage windings shall be aluminum with cast epoxy resin applied by a vacuum process. Each transformer shall include the following devices:

- a. Winding thermal sensors with termination box and digital temperature display unit.
- b. Ground connection provisions.
- c. Lifting lugs.

- d. Sliding rollers with mounting channels and provisions for seismic anchoring.
- e. Hooks for towing in all directions.
- [f. Electronic type temperature alarm and control unit with: (1) high temperature alarm feature; (2) high-high temperature shutdown feature; (3) all control devices for operating automatically controlled cooling fans; and (4) all associated control circuitry. Provide separate temperature sensors or combine operation with the digital temperature display unit.]

## 2.13 DC POWER SYSTEM

CEI UNI EN 45510-2-3 and CEI EN 60896-2. Provide DC power system including free standing enclosure panel, station batteries with battery rack, and battery charger. The system shall be suitable for the requirements of the [ high voltage switchgear][ and][ circuit breakers (individually mounted style)][ and all other loads indicated]. Batteries shall be [24][\_\_\_\_\_] V, lead-acid,[ pasted plate type][ or][ sealed, totally absorbed electrolyte type]. The DC power system shall be totally compatible with all equipment served. The system shall serve the[ switchgear][ and][ circuit breaker] controls,[ the low voltage switchboard main circuit breakers' trip system,][ the alarm system,][ and the emergency lights]. The capacity of the batteries shall be calculated by the high voltage[ switchgear][ circuit breaker] manufacturer and approved by the Contracting Officer before acceptance. The DC panel shall have a hinged lockable front door, main bus, ground bus, circuit breakers, terminal blocks, wiring and cable supports, and AC and DC overcurrent circuit protection. Provide DC load circuit breakers (quantity, ampacity, configuration, and so forth) as indicated on the drawings. The DC power system shall include manual and automatic charger control, a rheostat for DC voltage adjusting, and a DC voltmeter and ammeter. Indicator lamps shall be provided for indicating AC voltage, DC low voltage condition, DC load fed by battery, and DC system failure (an alarm status).[ The DC system failure alarm shall be connected to the alarm panel and shall activate this alarm system.] System shall include, but not necessarily limited to, the following:

- a. Pasted plate type batteries: Positive plates shall be of the manchester type and negative plates shall have a life equal to or greater than the positive plates. Battery containers shall be heat and impact resistant clear plastic with electrolyte level lines permanently marked on all four sides. A permanent leakproof seal shall be provided between cover and container and around cell posts. Sprayproof vent plugs shall be provided in covers. Sufficient sediment space shall be provided so that the battery will not have to be cleaned out during its normal life. High porosity separators to provide correct spacing between plates shall be provided.
- b. Sealed batteries: Provide batteries with leakproof, spillproof electrolyte utilizing highly absorbent material to separate the positive and negative plates. Battery jars shall be hermetically sealed with welded seams. Batteries shall be maintenance-free requiring no watering to be done.

- c. Battery charger shall be full-wave rectifier type, utilizing silicon semiconductor devices. Charger shall maintain a float charge of [2.15][\_\_\_\_] V per cell and an equalizing charge of [2.33][\_\_\_\_] V per cell. An equalizing charge timer shall be provided which operates automatically after an AC power failure of 5 seconds or more. Timer shall be adjustable for any time period up to 24 hours. Timer shall also be capable of being actuated manually. Adjustable float and equalizing voltage potentiometers shall be provided. Charger voltage shall be maintained within plus or minus 1/2 percent from no load to full load with AC line variations of plus or minus 10 percent and frequency variations of plus or minus 5 percent. Provide a DC voltmeter and ammeter with a minimum 90 mm scale and 2 percent accuracy of full scale. Output current shall be limited to 115 percent of rated output current, even down to short circuit of the DC output terminals. Solid state circuit shall have AC and DC transient voltage terminals. AC and DC magnetic circuit breakers shall be provided. Circuit breakers shall not be overloaded or actuated under any external circuit condition, including recharge of a fully discharged battery and short circuit of the output terminals. Charger shall be capable of continuous operation at rated current at an ambient temperature of 40 degrees C. Output DC current capacity shall match the requirements of the batteries provided.
- d. Provide steel battery rack, painted with two coats of acid resistant paint for mounting batteries. Provide lead-plated copper inter-rack connectors and cell numbers with each rack. Secure battery rack such that it can not overturn or be disrupted by lateral forces accompanying a seismic disturbance.

## 2.14 ALARM SYSTEM

The alarm system shall be totally compatible with the[ high voltage switchgear][ high voltage circuit breaker (individually mounted style)] and all other associated equipment. Additional spare auxiliary relays furnished with the[ switchgear][ circuit breaker] may be used for the alarm system as approved by the manufacturer. Coordinate with the manufacturer and provide an integrated system design. The alarm system shall consist of an alarm panel, audio and visual alarm devices, emergency shutdown switches, emergency auxiliary relay or relays, the auxiliary control relay (device 96), all annunciator lamps, associated switches, and all interconnecting circuitry. The system shall provide all functional operations defined herein and in the associated control diagrams included on the drawings. The auxiliary emergency relay(s) and auxiliary control relay shall be mounted in the alarm panel unless such components are integrated with the[ switchgear][ circuit breaker]. The alarm system shall operate at [24][\_\_\_\_] VDC and shall be supplied from the DC power system.

### 2.14.1 Alarm Panel

The alarm panel shall be solid state, permanently energized type, suitable to signal at least the following features (minimum conditions):

- a. General electrical failure of the[ switchgear][ circuit breaker]

(protective relays, transformer relays, circuit breaker tripping, and so forth). Transformer alarm features shall include high temperature alarm and high-high temperature shutdown alarm.

- b. General failure of battery or battery-charger.
- c. Emergency shutdown, manually activated.

#### 2.14.2 The following alarm sequence shall be provided:

- a. Alarm Feature: In case of alarm, the alarm horns shall sound and the alarm lights shall flash.
- b. Acknowledge Feature: Upon pushing a "silence" push-button switch, the alarm horns shall silence and the flashing lights shall illuminate at steady state.
- c. Clear Feature: Upon clearing the alarm conditions, pushing a reset push-button switch shall de-energize the alarm lights.
- d. Ringback Feature: The alarm panel shall include "ringback" feature in which the system shall activate in an alarm status should a subsequent alarm be activated after a prior alarm has been "acknowledged".
- e. Test Feature: A test push-button shall be provided for testing the alarm horns and alarm lights.
- f. Annunciation Features: The alarm panel shall have a panel mounted annunciator lamp which matches the operations of the outdoor alarm light. There shall also be an annunciator lamp for each alarm and status function specified and indicated on the drawings. All lamps and switches shall have nameplates in English and [Italian][\_\_\_\_\_]. All annunciator lamps shall have a "push to test lamp" feature. A consolidated test system (single test switch with control relay) may be provided in lieu of multiple individual test switches.

#### 2.15 INSULATED BARRIERS

Where insulated barriers are required by reference standards, provide barriers with 6 mm minimum thickness.

#### 2.16 FINISH

Exterior surface of the high voltage equipment shall be [light gray][\_\_\_\_\_][ and in accordance with the Station's color selection standards].

#### 2.17 CORROSION PROTECTION

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**NOTE: Choose the level of corrosion protection required for the specific project location. Galvanized steel should be the choice in most cases. Choose CEI 7-6 for hot-dip galvanized steel or UNI**

**EN 10088-1 for stainless steel.**

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[CEI 7-6][, ][UNI EN 10088-1]. Bases, frames, and channels of the high voltage equipment which come in contact with concrete shall be corrosion resistant and shall be fabricated of[ hot-dip galvanized steel][ or][ stainless steel]. Galvanize after fabrication where practicable.

**2.18 TERMINAL BOARDS**

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Terminal boards associated with current transformers shall be short-circuiting type. Terminate conductors for current transformers with ring-tongue lugs. Terminal board identification shall be identical in similar units. External wiring shall be color coded consistently for similar terminal boards.

**2.19 WIRE MARKING**

Mark control and metering conductors at each end. Provide factory-installed white plastic tubing heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide multiple white preprinted polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Each sleeve shall contain a single letter or number, shall be elliptically shaped to fit the wire securely, and shall be keyed, or otherwise arranged, in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Wire markers for factory installed conductors shall indicate wire designations corresponding to the schematic drawings. Wire markers on field installed conductors shall indicate the device or equipment, including specific terminal number to which the remote end of the wire is attached, as well as the terminal number to which the wire is directly attached (near end/far end marking).

**[2.20 SURGE ARRESTERS**

Provide one surge arrester for each conductor on circuits where indicated. Surge arresters shall be provided by the respective power equipment manufacturer and shall be as recommended by the manufacturer for the use intended.

**]2.21 NAMEPLATES**

Provide as specified in Section 16050, "Basic Electrical Materials and Methods".

**2.22 WARNING SIGNS**

Provide to comply with UNI 7545-7. Provide as specified in Section 16050, "Basic Electrical Materials and Methods".

**2.23 SOURCE QUALITY CONTROL**

Provide all tests in accordance with the requirements of the referenced standards of the respective electrical equipment.

#### 2.23.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

##### a. Test Instrument Calibration

1. The manufacturer shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to a recognized European institute of standards and technology.
3. Instrument calibration frequency schedule shall not exceed 12 months for both test floor instruments and leased specialty equipment.
4. Dated calibration labels shall be visible on all test equipment.
5. Calibrating standard shall be of higher accuracy than that of the instrument tested.
6. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
  - (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
  - (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

#### 2.23.2 High Voltage Switchgear Design Tests

Provide high voltage design tests on this equipment in accordance with the paragraph entitled "High Voltage Design Tests for Power Equipment".

#### 2.23.3 High Voltage[ Switches][ Switch Assembly] Design Tests

Provide high voltage design tests on this equipment in accordance with the paragraph entitled "High Voltage Design Tests for Power Equipment".

#### 2.23.4 High Voltage Circuit Breakers (Individually Mounted Style) Design Tests

Provide high voltage design tests on this equipment in accordance with the

paragraph entitled "High Voltage Design Tests for Power Equipment".

#### 2.23.5 High Voltage Design Tests for Power Equipment

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

Required tests shall be as follows:

- a. Dielectric:
  - 1. Low-frequency withstand
  - 2. Impulse withstand
- b. Continuous current
- c. Short-time current withstand (2 - second)
- d. Momentary current (10 cycles)
- e. Mechanical endurance
- f. Insulator Supports
  - 1. Flame-resistance
  - 2. Tracking-resistance
- g. Bus-bar insulation
  - 1. Dielectric Strength
  - 2. Flame-resistance
- h. Paint qualification
- i. Rain

#### 2.23.6 High Voltage Switchgear Production Tests

Provide high voltage production tests on this equipment in accordance with the paragraph entitled "High Voltage Production Tests for Power Equipment".

#### 2.23.7 High Voltage[ Switches][ Switch Assembly][ Switchgear] Production Tests

Provide high voltage production tests on this equipment in accordance with the paragraph entitled "High Voltage Production Tests for Power Equipment".

#### 2.23.8 High Voltage Production Tests for Power Equipment

Furnish reports of production tests performed on the actual equipment for this project. Required tests shall be as follows:

- a. Dielectric
- b. Mechanical operation
- [c. Grounding of instrument transformer case]
- [d. Electrical operation and control wiring]

#### 2.23.9 Transformer Design Tests (Liquid Insulated)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Design tests shall be made only on representative apparatus of basically the same design. Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[ each of] the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

- a. Tests shall be certified and signed by a registered professional engineer.
- b. Temperature rise: "Basically the same design" for the temperature rise test means a transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (OA), the same temperature rise rating, and the same insulating liquid as the transformer specified.
- c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests shall include both the primary and secondary windings of that transformer.
  - 1. State test voltage levels.
  - 2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.
- d. Lifting and moving devices: "Basically the same design" for the lifting and moving devices test means a transformer in the same weight range as the transformer specified.
- e. Pressure: "Basically the same design" for the pressure test means a transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

#### 2.23.10 Transformer Routine and Other Tests (Liquid Insulated)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Routine and other tests shall be performed by the manufacturer on[ each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

- a. Cold resistance measurements (provide reference temperature)
- b. Phase relation
- c. Ratio
- d. Insulation power-factor by manufacturer's recommended test method.
- e. No-load losses (NLL) and excitation current
- f. Load losses (LL) and impedance voltage
- g. Dielectric
  - 1. Impulse: Test the primary winding only.
    - (a) State test voltage levels
    - (b) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[ As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand-delivered at the factory witness test.]
  - 2. Applied voltage
  - 3. Induced voltage
- h. Leak

#### 2.23.11 Transformer Routine and Other Tests (cast resin)

CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[ each of] the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

- a. Tests shall be certified and signed by a registered professional engineer.
- b. Temperature rise: "Basically the same design" for the temperature rise test means a transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.
- c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary). Design lightning impulse tests shall include both the primary and secondary windings of that transformer.

1. State test voltage levels.
2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.
3. Partial Discharge Test.

#### 2.23.12 Transformer Design Tests (Dry Type)

EN 60726, CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Design tests shall be made only on representative apparatus of basically the same design. Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for[ each of] the specified transformer(s). Design tests shall have been performed prior to the award of this contract.

- a. Tests shall be certified and signed by a registered professional engineer.
- b. Temperature rise: "Basically the same design" for the temperature rise test means a transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (AA), the same temperature rise rating, the same insulating class and the same insulating medium as the transformer specified.
- c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary). Design lightning impulse tests shall include both the primary and secondary windings of that transformer.

1. State test voltage levels.
2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.
3. Partial Discharge Test.

#### 2.23.13 Transformer Routine and Other Tests (Dry Type)

EN 60726, CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-5. Routine and other tests shall be performed by the manufacturer on[ each of] the actual transformer(s) prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence shall be as follows:

- a. Resistance measurements
- b. Phase relation
- c. Ratio

- d. Insulation power-factor by manufacturer's recommended test method.
- e. No-load losses (NLL) and excitation current
- f. Load losses (LL) and impedance voltage
- g. Lightning impulse: Perform the complete design type impulse tests on the transformer primary winding only.
  - 1. State test voltage levels
  - 2. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test reports.[ As an alternative, photographs of oscilloscope display waveforms or plots of digitized waveforms may be hand delivered at the factory witness test.]
- h. Low frequency dielectric
  - 1. Applied voltage
  - 2. Induced voltage

### PART 3 EXECUTION

#### 3.1 INSTALLATION

Electrical installations shall conform to CEI 64-8,[ CEI 14-13 and CEI 14-8 for power transformers][ and][ CEI EN 62271-102, CEI EN 60265-1, CEI EN 60298, CEI EN 60694 and CEI 17-1 for high voltage switchgear][ and][ high voltage switches][ and][ high voltage circuit breakers (individually mounted style)]; as indicated on project drawings and the approved shop drawings; as instructed by the equipment manufacturer[s]; and as specified herein.

#### 3.2 GROUNDING

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**NOTE:** Where rock or other soil conditions prevent obtaining a specified ground value, other methods of grounding should be specified. Where it is impractical to obtain indicated ground resistance values, the designer should make every effort, within reason, to obtain ground resistance values as near as possible to the indicated values.

Provide drawing details of all grounding system features including ground rod inspection pits, ground bus bar system (mounted on insulators), equipment ground bars, and other specific grounding system components. Be sure to define the size of all ground conductors.

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CEI 64-8 and CEI 11-1. Provide ground system as specified in Section 16303, "Underground Electrical Work". When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

### 3.2.1 Grounding Electrodes

Provide driven ground rods as specified in[ Section 16303, "Underground Electrical Work"] [ and] [ Section 16301, "Overhead Transmission and Distribution"]. Connect ground conductors to the upper end of the ground rods by[ bolted connections that are located in easily accessible inspection pits][ exothermic welds or compression connectors]. Provide compression connectors at equipment ends of ground conductors.

### 3.2.2 Power Equipment Grounding

Provide bare copper conductors and cable as indicated. Provide all ground connections to the power equipment in accordance with the manufacturers' instructions and recommendations. Exterior ground conductors shall be buried not less than 600 mm below grade and connected to the indicated ground rods.[ Transformer neutral connections shall not be smaller than [\_\_\_] mm<sup>2</sup>.][ Fence and equipment connections shall not be smaller than 16 mm<sup>2</sup>. Ground fence at each gate post and cornerpost and at intervals not exceeding 3000 mm. Bond each gate section to the fence post through a 3 mm by 25 mm flexible braided copper strap and clamps.]

### 3.2.3 Connections

Make joints in grounding conductors[ and mats] by[ bolted connections that are located in easily accessible inspection pits][ exothermic weld or compression connector]. Connectors and connections shall be installed as specified in Section 16303, "Underground Electrical Work".

### 3.2.4 Ground Conductor Crossing Expansion Joints in Structures and Pavements

Protect ground conductors from damage by means of approved devices or installation methods to allow the necessary slack across the expansion joint. Provide stranded (braided) copper strap or other approved flexible copper assembly across such separations.

## 3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment, materials and miscellaneous devices furnished under this section as indicated on project drawings, the approved shop drawings, as specified herein, and in accordance with the manufacturers' instructions and recommendations.

### 3.3.1 Galvanizing Repair

For galvanizing damaged by handling, transporting, cutting, welding, or bolting, repair the damage to galvanized coatings using zinc rich paint provided by the associated equipment manufacturer. Do not heat surfaces that repair paint has been applied to. Provide paint which complies with

UNI 8744.

### 3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

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NOTE: Define on drawings the specific equipment required to have a concrete mounting slab. Mounting slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings. Do not provide interior slabs if raceway system is a subsurface cable trench system. Exterior locations are only allowed where specifically required by the Activity. Also, curbs or raised edges may be required around liquid filled transformers. Ensure specification Section 03300 is included in the final contract specifications.

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#### 3.4.1 Interior Location

Mount indicated equipment on concrete slab. Slab shall be at least 100 mm thick. Top of concrete slab shall be approximately 100 mm above finished floor. Edges above floor shall have 15 mm chamfer. Slab shall be of adequate size to project at least 200 mm beyond the equipment, except that front of slab shall be large enough to serve as a platform to withdraw breakers. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Conduits entering the slab, including the 90 degree elbow fittings, shall be rigid steel conduits. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

Cut off and bush conduits 75 mm above slab surface. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete".

#### 3.4.2 Exterior Location

Mount indicated equipment on concrete slab. Slab shall be at least 200 mm thick, reinforced with wire fabric 150 mm square and placed uniformly 100 mm from the top of the slab. Slab shall be placed on a 150 mm thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm above finished grade. Edges above grade shall have 15 mm chamfer. Slab shall be of adequate size to project at least 200 mm beyond equipment, except that front of slab shall be large enough to serve as a platform to withdraw breakers. Provide conduit turnups and cable entrance space required by the equipment to be mounted and as indicated. Conduits entering the slab, including the 90 degree elbow fittings, shall be rigid steel conduits. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm above slab surface. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete".

### 3.5 FIELD QUALITY CONTROL

### 3.5.1 Performance of Acceptance Checks and Tests

Perform acceptance checks and tests in accordance with Section 16081, "Apparatus Inspection and Testing," the manufacturer's recommendations, referenced standards, and requirements of the host nation. Perform tests specific to high voltage[ switchgear][ switches)][ circuit breakers (individually mounted style)][ power transformers,] relays, metering, and instrument transformers.[ Provide services of manufacturer's technical representative to perform testing and calibration of protective power relays and associated devices.] Perform tests to obtain information about the performance of breakers, meters, wiring, and instrument transformers together, as well as separately. The contracting Officer will witness formal tests after receipt of written certification that preliminary tests have been completed and that system is ready for final test and inspection.

Tests shall include those listed in the specified equipment's referenced publications and the following paragraphs.

#### 3.5.1.1 High Voltage[ Switchgear][ Switch(es)][ and][ Circuit Breakers (Individually Mounted Style)]

Perform in accordance with CEI 17-1, CEI EN 60060-2, CEI EN 60265-1, CEI EN 60298, CEI EN 60694, EN 62271-100, and CEI EN 62271-102.

##### a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Confirm correct application of manufacturer's recommended lubricants.
4. Verify appropriate anchorage and required area clearances.
5. Verify appropriate equipment grounding.
6. Verify correct[ blade][ contactor] alignment, penetration, travel stops, and mechanical operation.
- [7. Verify that fuse sizes and types correspond to approved shop drawings.]
- [8. Verify that each fuse holder has adequate mechanical support.]
9. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic surveying is not required.
10. Test interlocking systems for correct operation and sequencing.
11. Verify correct phase barrier materials and installation.
12. Inspect all indicating devices for correct operation

b. Electrical Tests

1. Perform insulation-resistance tests.
2. Perform over-potential tests.
3. Measure contact-resistance across each[ switch blade][ contactor][ and fuse holder].
- [4. Measure fuse resistance.]
5. Verify heater operation.

3.5.1.2 Transformers (Liquid Insulated)

Perform in accordance with CEI EN 60076-1, CEI EN 60076-2, CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-10, and CEI 14-13.

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.
- [3. Verify that cooling fans and pumps operate correctly and that fan and pump motors have correct overcurrent protection.]
- [4. Verify operation of all alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.]
5. Verify tightness of accessible bolted electrical connection by calibrated torque-wrench method. Thermographic survey is not required.
6. Verify correct liquid level in transformer tank.
7. Perform specific inspections and mechanical tests as recommended by manufacturer.
8. Verify correct equipment grounding.

b. Electrical Tests

1. Perform insulation-resistance tests.
2. Perform turns-ratio tests.
3. Perform insulation power-factor/dissipation-factor tests on windings.

4. Sample insulating liquid. Sample shall be tested for:
  - (a) Dielectric breakdown voltage
  - (b) Acid neutralization number
  - (c) Specific gravity
  - (d) Interfacial tension
  - (e) Color
  - (f) Visual condition
  - (g) Parts per million water
  - (h) Measure dissipation factor or power factor.
5. Perform dissolved gas analysis (DGA).
6. Test for presence of PCB.
7. Verify that the tap-changer is set at specified ratio.
8. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

#### 3.5.1.3 Transformers (Dry Type)

Perform in accordance with CEI EN 60076-1, CEI EN 60076-2, CEI EN 60076-3, CEI EN 60076-4, CEI EN 60076-10, EN 60726, and CEI 14-8.

##### a. Visual and Mechanical Inspection

1. Compare equipment nameplate information with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify that control and alarm settings on temperature indicators are as specified.
- [4. Verify that cooling fans operate correctly and that fan motors have correct overcurrent protection.]
5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.
6. Perform specific inspections and mechanical tests as recommended by manufacturer.
7. Make a close examination for shipping brackets or fixtures that may not have been removed during installation and ensure that

resilient mounts are free.

8. Verify that winding core, frame, and enclosure groundings are correct.
9. Verify that as-left tap connections are as specified.

b. Electrical Tests

1. Perform insulation-resistance tests.
2. Perform power-factor tests or dissipation-factor tests in accordance with the test equipment manufacturer's instructions.
3. Perform turns-ratio tests.
4. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.
5. Perform overpotential test on all high- and low-voltage windings-to-ground.

3.5.1.4 Current Transformers and Voltage Transformers

Perform in accordance with CEI EN 60044-1, CEI EN 60044-2, and CEI EN 60934.

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify correct connection.
4. Verify that adequate clearances exist between primary and secondary circuit.
5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.
6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform insulation-resistance tests.
2. Perform polarity tests.
3. Perform ratio-verification tests.

3.5.1.5 Metering and Instrumentation

Perform in accordance with CEI EN 61010-1 and CEI 64-8.

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters.
2. Calibrate meters according to manufacturer's published data.
3. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.6 Grounding System

Perform in accordance with CEI 64-8 and CEI 11-1.

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

1. Electrical test shall be as defined in Section 16303, "Underground Electrical Work".

[3.5.2 Field Dielectric Tests

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**NOTE: Field dielectric tests are recommended when new units are added to an existing installation or after major field modifications. If necessary, service the equipment prior to the field test.**  
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Perform field dielectric tests on high voltage equipment according to referenced standards and the manufacturers' instructions and recommendations.

]3.5.3 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Circuit breakers shall be tripped by operation of each protective device.

Test shall require each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer[ 5][ 10] working days in advance of the dates and times for checks, settings, and tests.

-- End of Section --